RF coupler parameter range for XFEL linac

(design status Nov. 2003)

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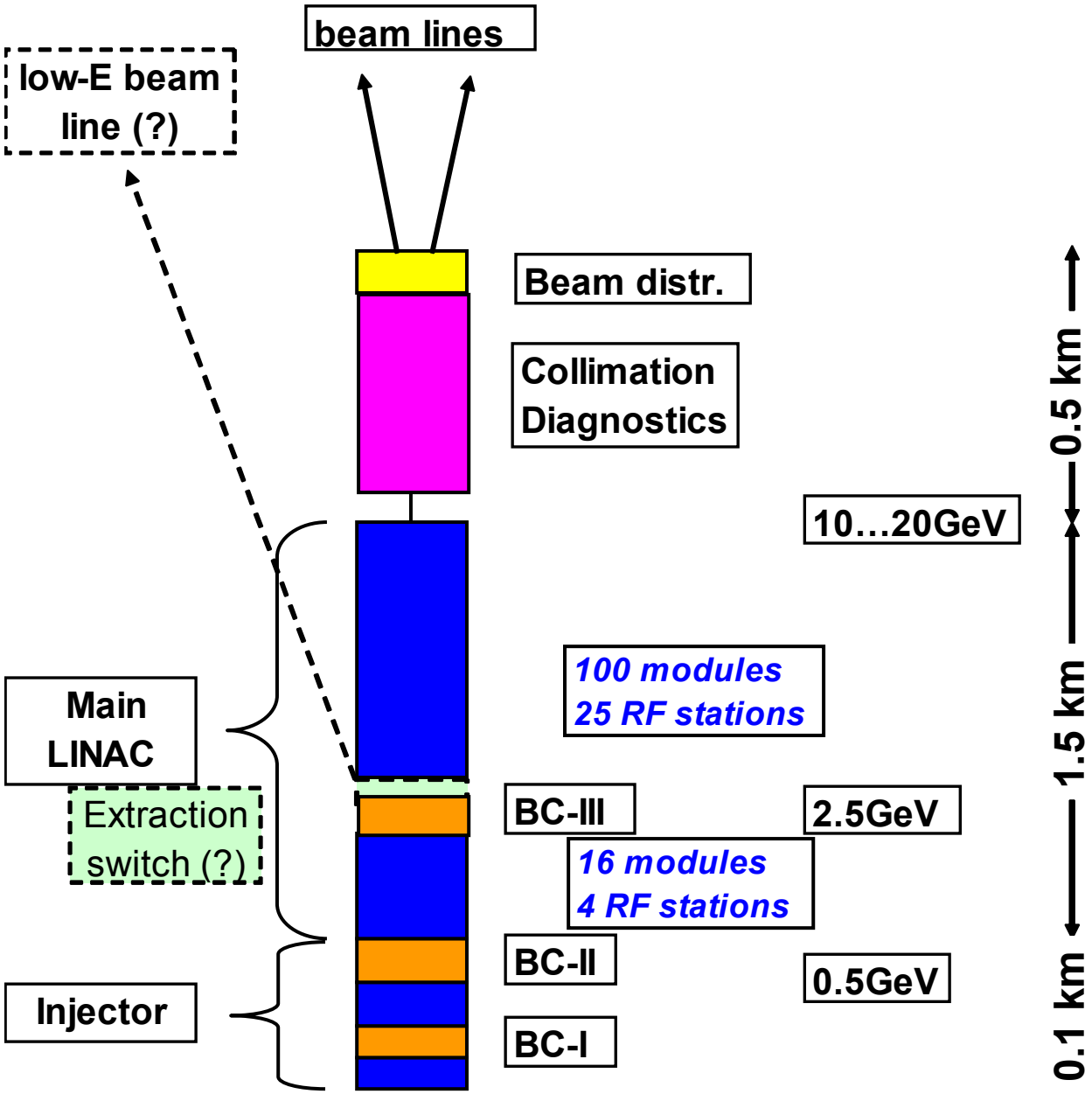

beam lines
low-E beam line (?)
Beam distr.
Collimation
Diagnostics
10…20GeV
100 modules
25 RF stations
Main
LINAC
Extraction
switch (?)
BC-III
2.5GeV
16 modules
4 RF stations
BC-II
0.5GeV
Injector
BC-I
0.5 km
1.5 km
0.1 km

reference parameter set:

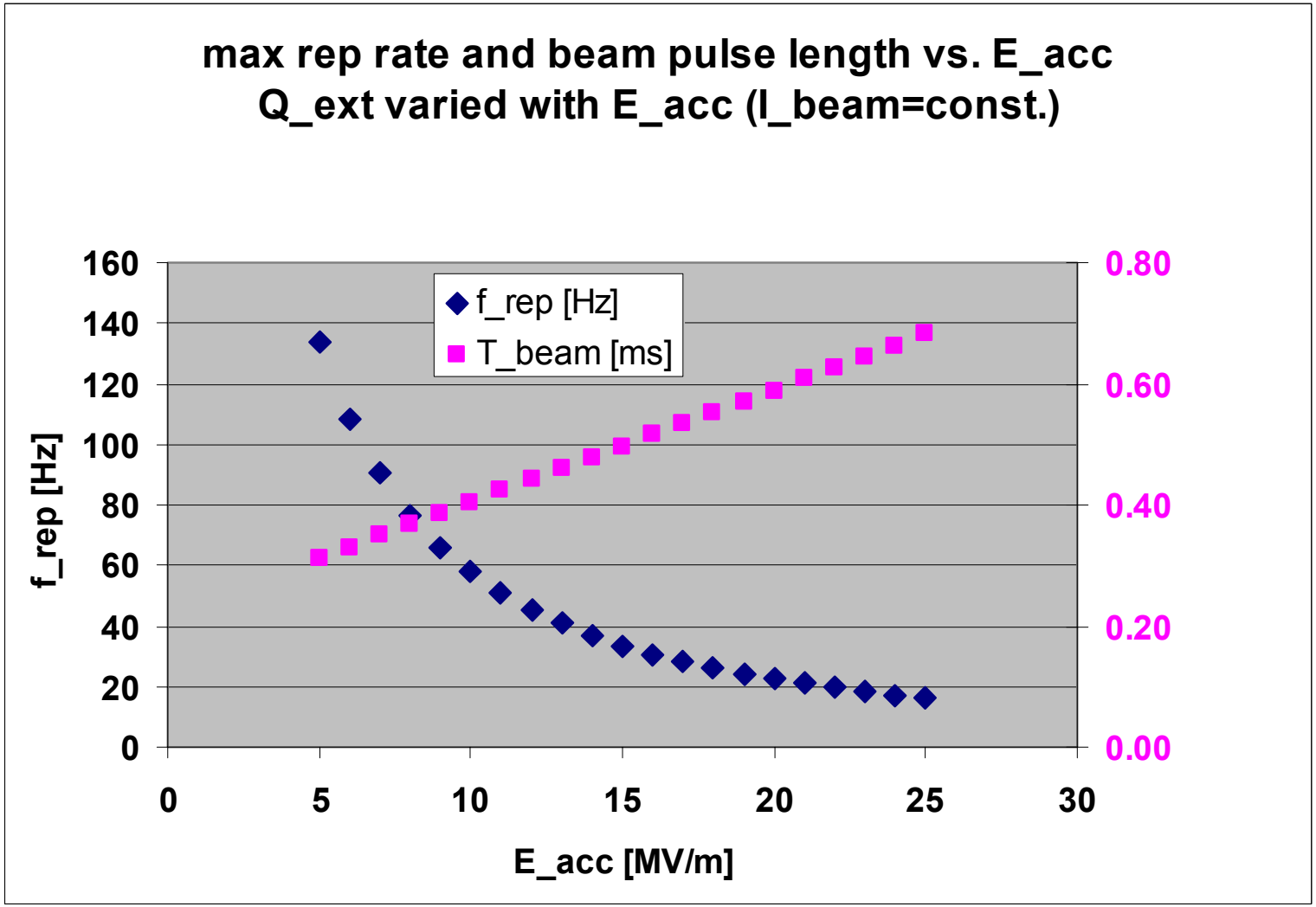
(ignore lower energy+injector sections for the moment – BC concept being re-viewed…)

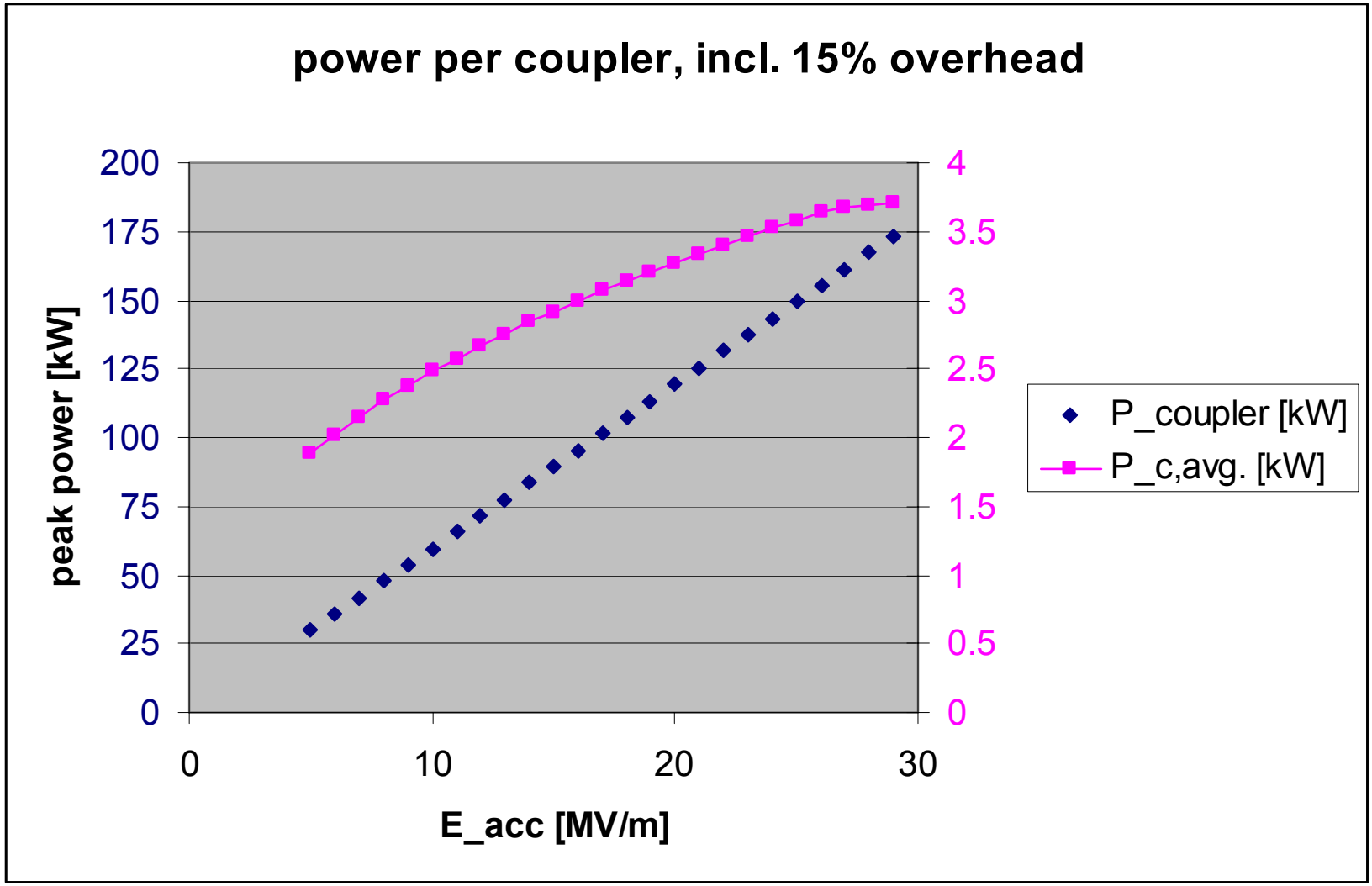
Main linac Section 2	
Energy gain	2.5 → 20 GeV
# installed modules	100
# active modules	92
acc gradient	22.9 MV/m
# installed klystrons	25
# active klystrons	23
beam current	5 mA
power→beam p. klystron	3.8 MW
incl. 10% + 15% overhead	4.8 MW
matched Q_{ext}	$4.6 \cdot 10^6$
RF pulse	1.37 ms
Beam pulse	0.65 ms
Rep. rate	10 Hz
Av. Beam power	650 kW

Conceivable parameter range, including future upgrades

- Maximum rep rate vs. acc. Gradient:
  - Assume limitation by RF-, not cryo system
  - Variable Q_ext ~ E_acc desirable for lower energy/higher rep rate operation with constant pulse current and shorter beam pulse
- → minimum reasonable Q_ext = $1.5 \cdot 10^6$ for E_beam ≅ 7 GeV

Example for rep rate vs energy scaling:





Note: average power includes filling time!

- Longer term potential for CW operation at lower energy:
  - Low-current, ~few 10kHz/1nC continuous beam
  - Extension to higher (few 100 kHz – 1Mhz/1nC) “virtual” current with ERL scheme (any users for this???)
- Simple consideration:
  - At ~zero current, RF power per coupler at 4.6×10^6, 23MV/m in steady state is 30kW (+ X for regulation, small beam loading)
  - Reasonable cryo power → reduce gradient by factor sqrt(10)
  - increase **Q_ext to 1.5×10^7**
- → RF power per coupler ~1kW (+ X)
  - **CW RF system with ~50kW per station!**

Summary

An RF coupler with the following capabilities would cover all presently conceivable operating parameters for the XFEL linac:

150 kW peak power, 3.5 kW average power, tuning range for $Q_{ext} = 1.5 \times 10^6 – 1.5 \times 10^7$

If 3-stub tuners can provide a tuning range by a factor of three in both directions, a fixed coupler at ~ 4.6×10^6 would be acceptable